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Evaluation of Morphological Traits in Some Castor Plant Genotypes in Isfahan Climate Condition

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ABSTRACT

Castor plant with the scientific name *Ricinus communis* L. is one of the oil plants of the Euphorbiaceae family cultivated in many parts of Iran. Castor plant is one of the important medicinal plants used in the cosmetic, health and pharmaceutical industries. Its medicinal properties are associated with the presence of phytochemical compounds such as alkaloids, flavonoids and tannins. The purpose of this study is to study the morphological characteristics of 15 different genotypes of castor bean plants under the climatic conditions of Isfahan province. This research was conducted in the form of a randomized complete block design and three replications in the research farm of Islamic Azad University, Isfahan (Khorasgan) Branch in the year 1400-1401, located in eastern Isfahan, Khatunabad. Average comparisons between the investigated genotypes showed that the Isfahan genotype had the lowest number of clusters and the highest plant height and stem length. Jiroft and Malair genotypes had the highest number of clusters with 5 and 4 clusters, respectively. Jiroft, Fars and Mashhad genotypes had a capsule size of 2.6 cm. Mashhad, Shahrekord and Zahedan genotypes had the highest number of leaves with 34, 33 and 29 respectively, and Mashhad and Shahrekord genotypes had the highest and lowest weight per thousand seeds with 524.61 grams and 132.72 grams, respectively. Mashhad and Jiroft genotypes had 23 and 21 sub-branches, respectively. In addition, the Shahrekord genotype was the lowest with a seed width of 6.89 mm. Jiroft and Shahrekord genotypes had the highest and lowest stem cross-sectional areas with 3 cm2 and 1.3 cm2, respectively. In general, there is considerable genetic diversity between castor plant genotypes in terms of morphological characteristics. High yields of 1,000 seed weight, capsule size and cross-section are available to the food and pharmaceutical industries by growing Mashhad, Fars and Jiroft genotypes in Isfahan.

Keywords: Castor, Genotype, Morphological characteristics, Climate, 1000 seed weight

INTRODUCTION

The castor bean plant with the scientific name *Ricinus communis* L. and the English name Castor Bean belongs to the oil plant family Euphorbiaceae. The castor plant is known as Nakhel Masih and is widely distributed in tropical regions. This is a fast-growing perennial plant. The leaves are green or reddish, about 30-60 cm in diameter, with 5 -12 deep lobes and coarsely serrated cross-sections. The leaves are placed alternately on the stem. The stems are different in terms of pigmentation. The fruit of this plant is a spiny three-core capsule. Seed sizes of different genotypes differ greatly from each other. The seeds are oval and the shell is smooth, thin and fragile. They vary in size from 8–18 mm in length and 4–12 mm in width, depending on genotype (Genna, 2013).

The castor plant has a very strong main root that penetrates to a depth of 3 meters in the soil. Its stem is hollow, woody, and multi-branched, and the leaves are bluish-green, gray, purple, or red, sometimes with a wax membrane and sometimes without wax (Arshi, 1988; Koutroubas *et al*., 1999). Large and wide leaves with long fanned and lipped petioles are seen in green (in green varieties) and red (in red varieties). The flowers are unisexual and small, and they are located on a panicle-like inflorescence called a candle. Male flowers at the bottom and female flowers at the top are without petals. This plant has prickly fruits with a soft capsule with three pointed seeds (similar to pinto beans) with a green and red background (Dovadeh Emami and Majnoon Hosseini, 2007). Due to its unique feature, the castor plant is known as one of the plants resistant to different weather conditions, so in cold regions it is a herbaceous and annual plant whose height reaches 2 to 3 meters (Marter, 1981). In tropical regions, it is a perennial shrub and its height reaches more than three meters. The low number of castor branches is one of the most important morphological characteristics that is effective in mechanized harvesting (Koutroubas *et al*., 2000). The plants of this family have various herbaceous, fleshy, shrub or tree forms. The leaves are alternate or alternate and usually have ear-rings. In fleshy ferns, the leaves have turned into thorns. The inflorescence is a spike. In Euphorbia and some other genera, the inflorescence consists of 5 one-sided, spiral-shaped spikes, in which there are male flowers with one stamen along with one female flower. The pistil is three-cartilaginous and pedunculate, and the flowers are located in a continuous raceme. This type of inflorescence is called Cyathium. In some plants of this family, the number of stamens is numerous and they are seen as free or continuous together or branched. The ovary is three-chambered and in each chamber, there are 2 inverted ovules in a hanging position with axial support. The free part of the pistil leads to the style of 3 branches. The fruit is a capsule, drupe or berry.

After ripening, the capsule fruit is divided into three parts and each one returns with a longitudinal slit. The seeds have an oily albumen and a relatively large and curved plant. In the internal building of these plants, internal drains and latex tubes can be seen, and these tubes are poisonous (Mortazainejad and Shirani, 2011).

In an experiment conducted by Baldwin and Cossar (2009), the effect of cultivation date, climate and the mutual effect of these two factors on castor yield in the central part of South America were discussed. The results of this study indicated that in a certain region, with a delay in cultivation, after a certain time, castor yield decreases. Delaying cultivation after a period of time reduced castor oil yield. Of course, this period varies depending on the field of study (Silva, 2005).

In general, the morphologies that can be examined include root morphology and its types, stem morphology and its types, leaf morphology and its types, flowers, inflorescences and fruits (Mortezainejad and Shirani, 2013).

In the study of genetic diversity and 20 morphological characteristics of castors collected from different geographical regions of Egypt and its cultivation in dry conditions, it showed that based on the characteristics of leaves, pollen grains, seeds and capsules, there are two morphological patterns in the native genotypes of this country (Shaheen, 2002). Yield variability can occur due to the impact of many factors on plants, including weather conditions, planting placement, planting date, plant population, growing practices, farm management, and diet (Anjami, 2005).

In the study of genetic diversity and 20 morphological characteristics of castors collected from different geographical regions of Egypt and its cultivation in dry conditions, it showed that based on the characteristics of leaves, pollen grains, seeds and capsules, there are two morphological patterns in the native genotypes of this country (Shaheen, 2002). Therefore, in this research, by collecting castor plant seeds from 15 different regions in Iran the morphological characteristics were investigated.

MATERIAL AND METHODS

Place of experiment

This research was conducted during the years 1400 to 1401 in the research farm of Islamic Azad University, Isfahan (Khorasgan) Branch, located in the east of Isfahan, Khatun Abad region. The place of this research is located at latitude 32 degrees and 40 degrees north and longitude 51 degrees and 48 minutes east. The height above the sea level is 1555 meters and the climate of the region is dry and very hot, so that it has relatively cold winters and hot and dry summers. This research was conducted in several stages: collecting seeds from different places, preparing the land, cultivating seeds, and examining the morphological characteristics of different genotypes.

The seeds required for this research were collected from 15 different regions of Iran including Isfahan, Varamin, Sari, Zahedan, Iranshahr, Shahrekord, Jiroft, Malayer, Tabriz, Rezen Tabriz, Hamadan, Borkhar, Fars, Abarkooh Yazd, and Mashhad were planted in the farm of Islamic Azad University, Isfahan (Khorasgan) Branch in the spring of 1400. To prepare the land, before plowing, first test the soil of the field to determine the type of soil which we are cultivating. Then the soil sample was analyzed and described in Table 1.

Table 1. Soil analysis

soil pattern	%silt	%sand	%clay	Absorbable potassium (mg/kg)	Absorbable phosphorus (mg/kg)	%SP[1]	total nitrogen (percent)	Gypsum (Percent)	lime (Percent)	organic carbon (percent)	pH	EC (ds/m)
SiCL	52	11	37	510	58	58	0/061	0/08	43	0/57	7/8	8/5

In this research, the method of sowing was considered as ridge planting. The distance between the rows was one meter and the distance between the plants on the row was considered to be half a meter (Shidfar *et al.*, 2010). In total, three rows of five meters in length were created for each genotype. Before planting, the seeds were soaked in water for 48 hours to facilitate germination. At the time of planting, holes with-1-meter intervals were created and seeds sown at a depth of 5-7 cm. The manual method was also used to remove weeds. To irrigate the seeds, irrigation tape or drip irrigation was used. The first irrigation was done immediately after planting the castor seeds, and the subsequent irrigations were done every 4 days using drip irrigation and were completely identical for all lines. After about 180 days, the growth period of castor plants was completed. At this time, the morphological properties of plants in different genotypes were investigated in the field and Laboratory.

Determination of morphological characteristics

Plant height and main cluster height above the ground are the most important morphological features of this plant (Weiss, 2000). To check this index, the plants of each line were measured separately using a meter.

To measure the number of clusters and cluster length, the number of clusters per plant was counted.

The location of the first cluster in Castor varies between the 6th and 12th nodes (Weiss, 2000). For this purpose, a meter was used to measure from the origin of the first capsule to the end of the last capsule. When the mature plants and the clusters were completely ripe, the number of leaves of each plant of each genotype was started to be counted. To measure leaf length, it was done with a meter from the tip of the leaf to the point where the leaf is connected to the petiole. Since each genotype has different numbers of sub branches, we also examined the number of sub branches in each plant. To measure seed length, width and diameter, the seeds were first removed from the capsules and each seed was individually measured with a vernier caliper. Different castor genotypes had different seed sizes. The number of inflorescences depends on the variety and cultivation conditions. In good growing conditions, the clusters will be full of flowers and more capsules will form (up to 300 capsules), and on the contrary, in dry years, the number of capsules may decrease to about 5-

[1] -Soil saturation percentage

10 capsules per cluster (Arshi, 1988; Vanderwolf *et al*., 1995). Therefore, seed yield in castor depends on the number of plants per unit area, the number of inflorescences per plant, the number of capsules in the first inflorescence, the number of seeds in a capsule and the weight of 1000 seeds (Koutroubas *et al*., 2000). To determine the weight of 1000 seeds, we first decapsulated seeds of each genotype and isolated 1000 seeds from each genotype. Then the seeds were placed in a suitable container and in the next step, they were weighed individually using a digital scale. To check the cross-sectional area of the stem, first the stem was cut in half, then the cross-sectional area of the stem of each genotype was measured using a vernier caliper. Once the plant is mature and the panicle is fully mature, start separating the panicle from the plant. Then the capsules were separated from the clusters and each capsule was measured with a vernier caliper.

Statistical analysis

Statistical analysis of the data was done using SAS software. In this research, the randomized complete block design and the comparison of the means were done by the least significant difference (LSD) test at the probability level of 1%. Excel software was also used to draw graphs.

RESULTS

Plant height

ANOVA results showed significant differences between castor genotypes concerning plant height. (Table 2). The comparison of the averages also indicated that the Isfahan genotype has the highest plant height (130 cm) and Fars and Malayer genotypes have the lowest plant height (57 cm). The Zahedan genotype also had a plant height of 122 cm and was placed in a statistical group with the Isfahan genotype (Figure 1). By studying several castor genotypes, Shidfar *et al*. (2013) reported a large and significant phenotypic and genotypic diversity and concluded that by performing selection, it is possible to improve this characteristic. They also reported that suitable environmental conditions, irrigation or increased competition for light will increase the height of the plant. The higher the height above the ground, the easier the mechanical harvesting of the clusters. Based on the obtained results, it can be said that the genotype of Zahedan is compatible with the climate of Isfahan, which led to an increase in its height.

Table 2. Variance analysis of traits of plant height, number of clusters, number and length of leaves

		average of squares			
Sources of changes	Degrees of freedom	leaf length	number of leaves	Number of clusters	Plant height
Block	2	17/41	19/27	0/156	19/29
treatment (areas)	14	117/32**	179/94**	5/070**	1794/84**
Test error	28	8/08	10/12	1/084	57/65
Coefficient of variation (%)		11/63	16/57	19/85	8/17

** Significant at the 1% probability level

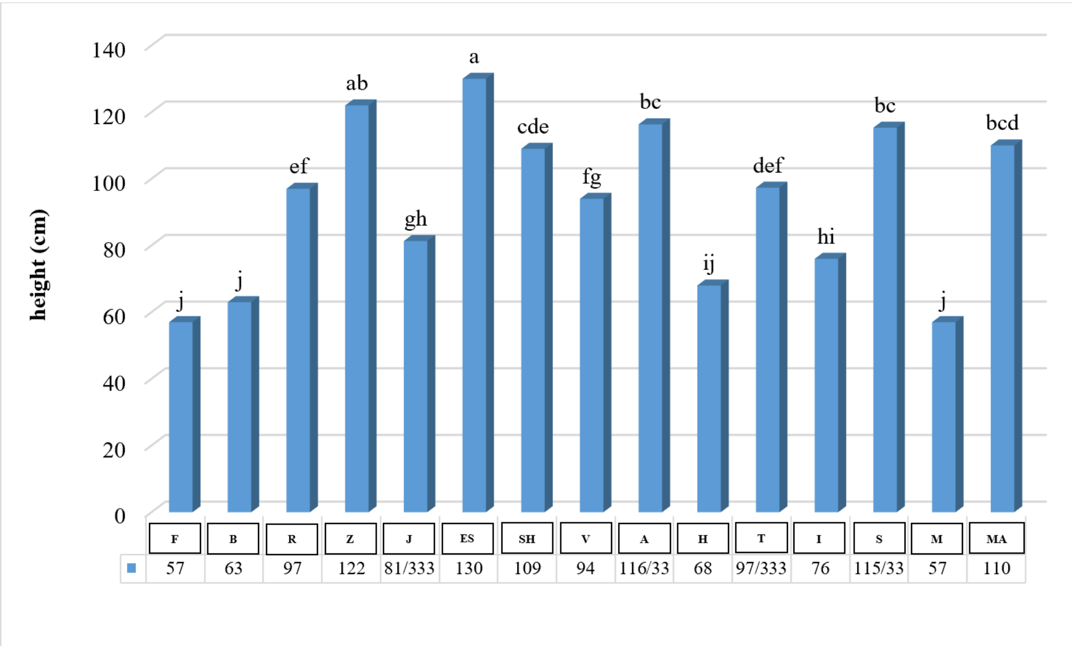

Figure1. Average comparison of castor genotypes in terms of plant height trait. Fars (F), Borkhar (B), Rezen (R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Number of clusters

Variance analysis showed that there is a significant difference between castor genotypes in terms of cluster number (Table 2). Comparing the averages also indicated that Jiroft genotype has the highest number of clusters (5) and Fars, Isfahan, Zahedan, Varamin and Tabriz genotypes have the lowest number of clusters (1). Malayer genotype also had 4 clusters and was placed in the same statistical group as Jiroft genotype (Figure 2). Kittock *et* *al*. (1967) stated that the supply of water and the environmental conditions and climate of the place of castor plant cultivation are effective on the number of clusters, the number of capsules, and the weight of 1000 seeds (Mousavi *et al*., 2015). Therefore, based on the results of our research, we can conclude that the climate and environmental conditions compatible with Jiroft genotype led to the production of more branches in this genotype compared to other genotypes.

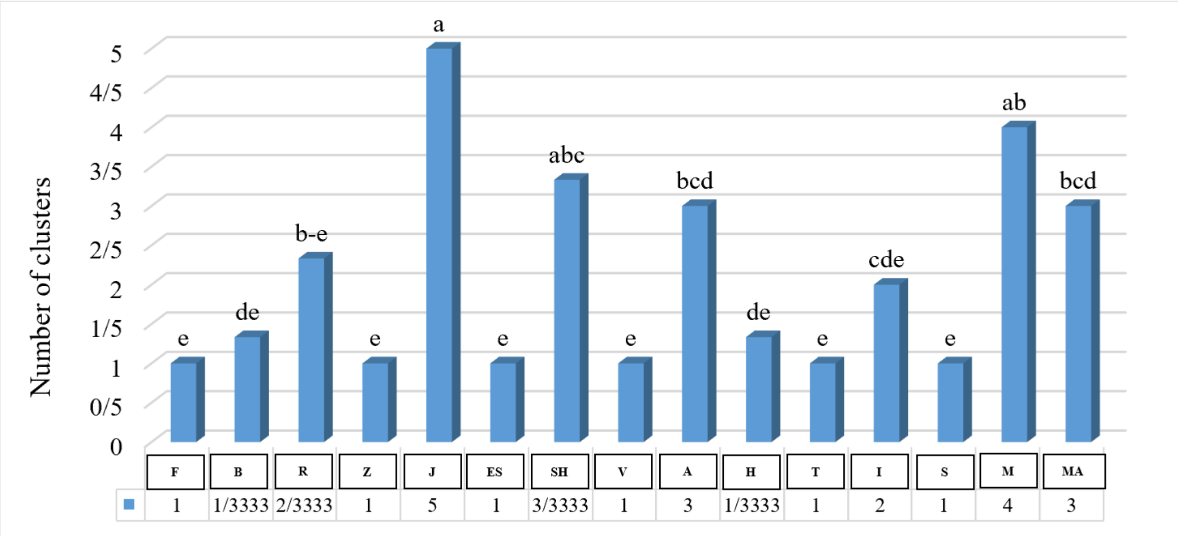

Figure 2. Average comparison of castor genotypes in terms of Number of clusters. Fars(F), Borkhar(B), Rezen(R), Zahedan(Z), Jiroft(J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Number of leaves

Variance analysis showed that there is a significant difference between castor genotypes in terms of leaf number (Table 2). Comparing the averages also indicated that Mashhad genotype has the highest number of leaves (34) and Varamin genotype has the lowest number of leaves (9). Shahrekord and Zahedan genotypes were placed in the same statistical group as the Mashhad genotype with averages of 33.33 and 29 leaves, respectively (Figure 3). Leaves are the source of photosynthesis and assimilate production. Increasing the number of leaves to a reasonable and permissible number will increase photosynthesis and of course increase the yield (Torres *et al*., 2015). According to the obtained results, it can be seen that the Mashhad genotype, unlike the Varamin genotype, is compatible with the climate of Isfahan and has high performance. This led to the formation of large capsules in this genotype, which ultimately affected plant performance.

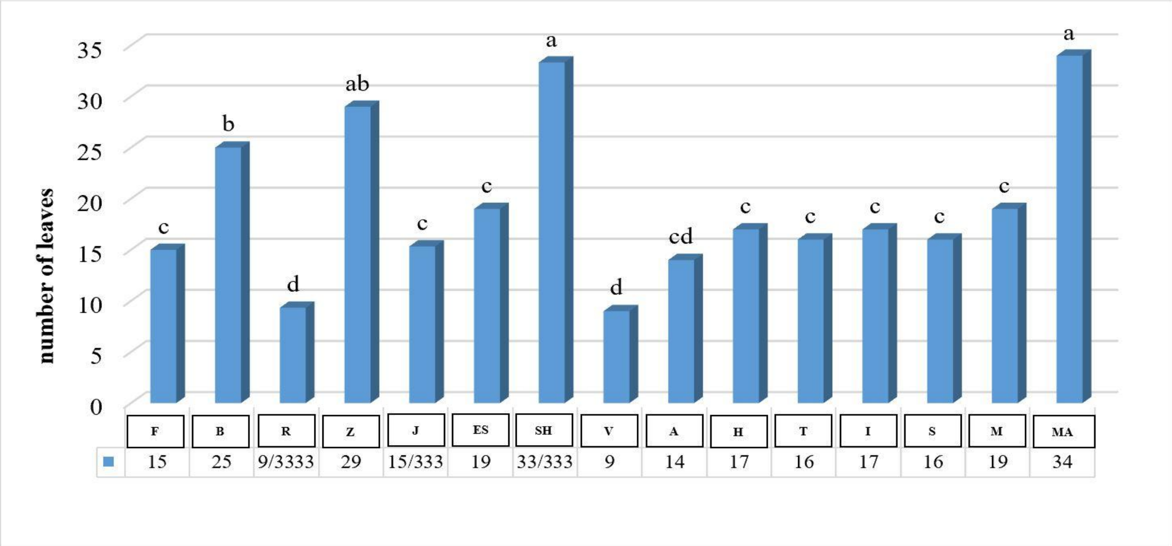

Figure 3. Average comparison of castor genotypes in terms of leaf number trait. Fars (F), Borkhar (B), Rezen (R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Leaf length

Analysis of variance showed that there is a significant difference between castor genotypes in terms of leaf length (Table 2). The comparison of the averages also indicated that Isfahan genotype has the longest leaf length (40.33 cm) and Malayer genotype has the lowest leaf length (15 cm). Fars and Borkhar genotypes were placed in the same statistical group as Malayer genotype, having an average leaf length of 17 cm (Figure 4). During the research, the Isfahan genotype had the highest leaf length after the Jiroft genotype, it can be said that the climatic conditions and increased cell division in the plant parts in this genotype have a significant relationship with this issue.

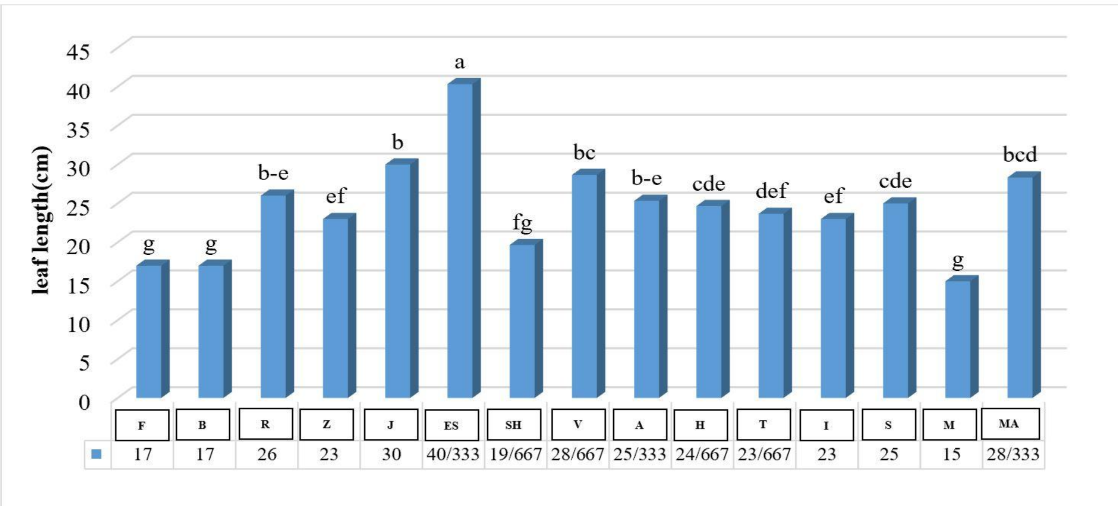

Figure 4. Average comparison of castor genotypes in terms of leaf length trait. Fars (F), Borkhar (B), Rezen (R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Cluster length

Variance analysis showed a very significant difference between the average castor genotypes in terms of spike length trait (Table 3). Comparing the average of genotypes using the minimum significant difference method at the 5% probability level also indicated that Jiroft genotype has the highest average cluster length of 48.33 cm. On the other hand, Iranshahr genotype had the lowest average spike length (12 cm). Other genotypes were in the middle of these two genotypes and showed a significant difference, especially with Jiroft genotype (Figure 5). Timely cultivation, rational growing season and better utilization of environmental conditions would likely increase the height of the main clusters (Loretti *et al*., 1998; Aliari *et al*., 2000). Looking at the cultivation of different genotypes in the Isfahan region, we can observe the effect of climate on the length of clusters of different genotypes. Also, plant growth regulators play an essential role in the growth and development of plants (Mousavi *et al*., 2015). The findings are consistent with Mohammadi's findings.

Table 3. Variance analysis of cluster length traits, number of sub-branches, seed length and width

		average of squares			
Sources of changes	Degrees of freedom	seed width	Seed length	Number of sub-branches	Raceme length
Block	2	0/033	0/0704	0/200	0/689
treatment (areas)	14	1/453**	7/3810**	98/038**	319/327**
Test error	28	0/029	0/1160	2/367	6/189
Coefficient of variation (%)		2/02	2/71	12/34	8/79

**: Significant at the 1% probability level

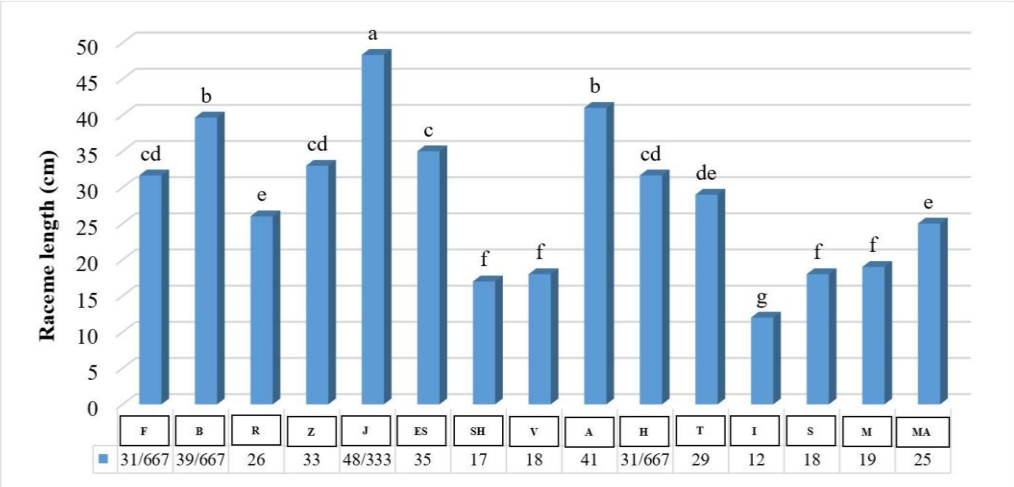

Figure 5. Average comparison of castor genotypes in terms of spike length trait. Fars (F), Borkhar (B), Rezen (R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Number of sub-branches

The results showed the existence of a difference at the probability level of 1% between castor genotypes in terms of the number of sub-branches (Table 3). Comparing the average of genotypes also confirmed the existence of significant differences between genotypes. Mashhad and Iranshahr genotypes with 23 branches had the highest average. Jiroft genotype also had an average of 21 branches and had no significant difference with Mashhad and Jiroft genotypes. The lowest number of sub-branches was assigned to Borkhar (6) and Malayer (6.33) genotypes, although they were not significantly different from each other (Figure 6). During research on castor, Shidfar et al. (2013) stated that the number of sub-branches of the Shahreza variety has been able to achieve the highest number due to the better use of environmental conditions, highly competitive power and also its genetic characteristics. According to the obtained results, it can be said that Mashhad and Iran Shahr genotypes have more divergence due to their genotypes and to make better use of environmental conditions.

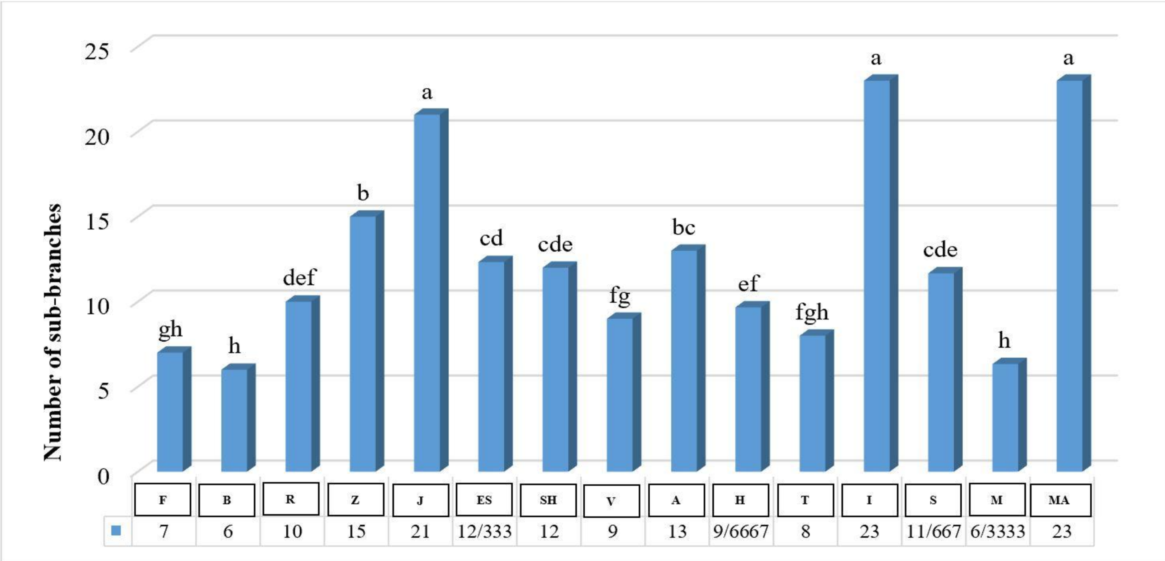

Figure 6. Average comparison of castor genotypes in terms of number of sub-branches trait. Fars (F), Borkhar (B), Rezen (R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer(M), Tabri (T) and Mashhad (MA)

Seed length

Analysis of variance of trait seed lengths showed that the difference between mean genotypes for this trait was highly significant (Table 3). Comparing the average of genotypes for this characteristic also confirmed the existence of a significant difference. The highest average seed length (14.67 mm) was assigned to Borkhar genotype. Sari and Rezen genotypes were placed in the same statistical group with an average of 14.58 and 14.35, respectively, and the average difference of these three genotypes was not significant. Shahrekord genotype had the lowest seed length at 9.34 mm and had a significant difference with all genotypes (Figure 7). According to the report of Koutroubas *et al*. (1999), increased irrigation, increases seed size, seed yield, and dry matter accumulation within the castor plant. Therefore, it can be concluded that this characteristic is influenced by the interaction of climate and genotype. Because Sari and Rosen genotypes had longer seed lengths than other genotypes due to growth in temperate regions.

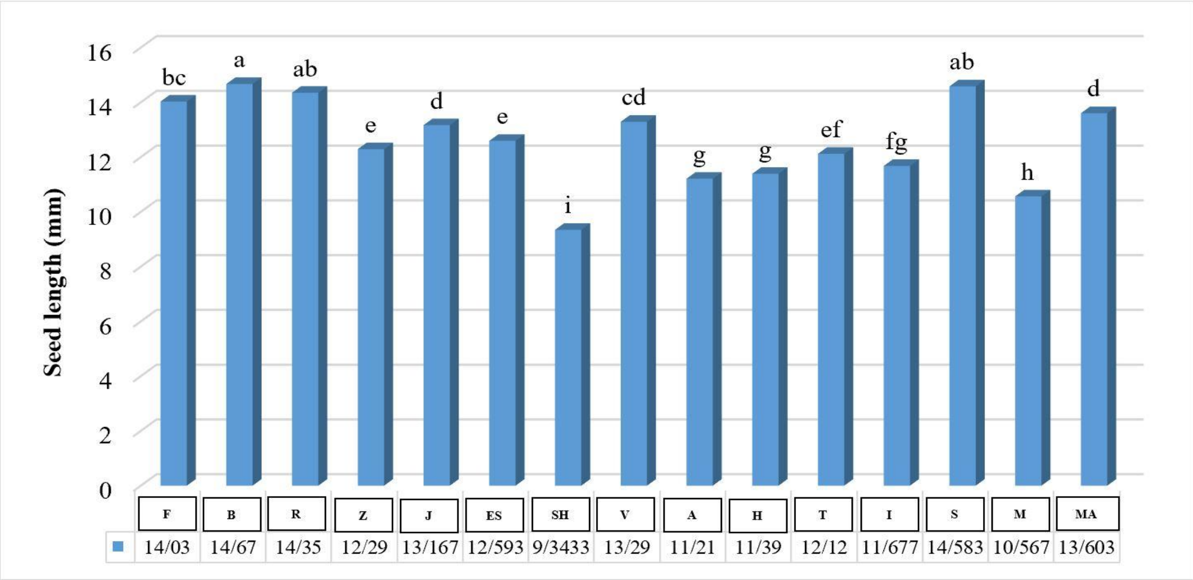

Figure 7. Average comparison of castor genotypes in terms of seed length trait. Fars(F), Borkhar(B), Rezen (R), Zahedan(Z), Jiroft(J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Seed width

The results of the variance analysis of the seed width trait indicated the existence of a very significant difference between the averages of the studied genotypes (Table 3). Comparison of the averages also showed that Sari and Borkhar genotypes had an average of 9.28 and 9.13 mm of seed width, respectively, and had the highest averages. Shahrekord genotype also ranked last with 6.89 mm seed width and had the lowest average (Figure 8). Zareh *et al*. (2015) also reported a similar result regarding the presence of variation in the seed width.

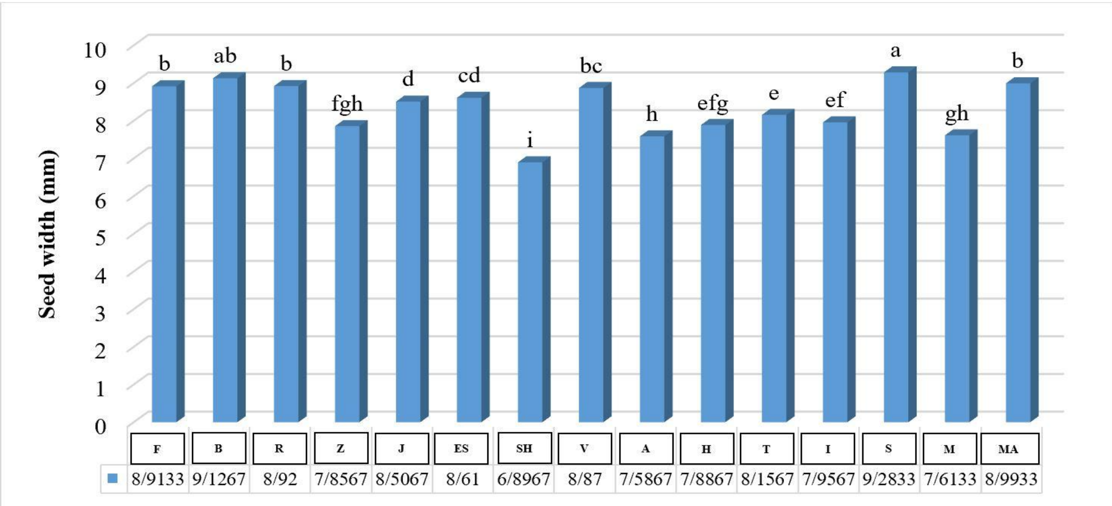

Figure 8. Average comparison of castor genotypes in terms of seed width trait. Fars(F), Borkhar (B), Rezen(R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin(V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Seed diameter

The results of segmentation and data show that there is a significant difference in cars between the two types of cars because of the characteristics of seed diameter (Table 4). The comparison of the sizes of these flankers with 6/83 and 5/05 mm in diameter of 2 cm and 2 cm in diameter is carried out on a regular basis. Other genotypes fell intermediate between these two genotypes. Fars, Rezen, Varamin, Sari and Mashhad genotypes were included in the same statistical group with Borkhar genotype (Figure 9). Relatively similar results regarding seed diameter have been obtained by Zareh *et al*. (2015) and Shahin (2002).

Table 4. Variance analysis of traits of seed diameter, 1000 seed weight, stem cross section, capsule size

		average of squares			
Sources of changes	Degrees of freedom	Capsule size	Cross section of stem	the weight of one thousand seeds	Seed diameter
Block	2	0/00867	0/0242	1/00	0/0039
treatment (areas)	14	0/80190**	0/7340**	40241/20**	0/9309**
Test error	28	0/01486	0/0090	3/00	0/0402
Coefficient of variation(%)		6/30	5/17	0/65	3/28

** : Significant at the 1% probability level

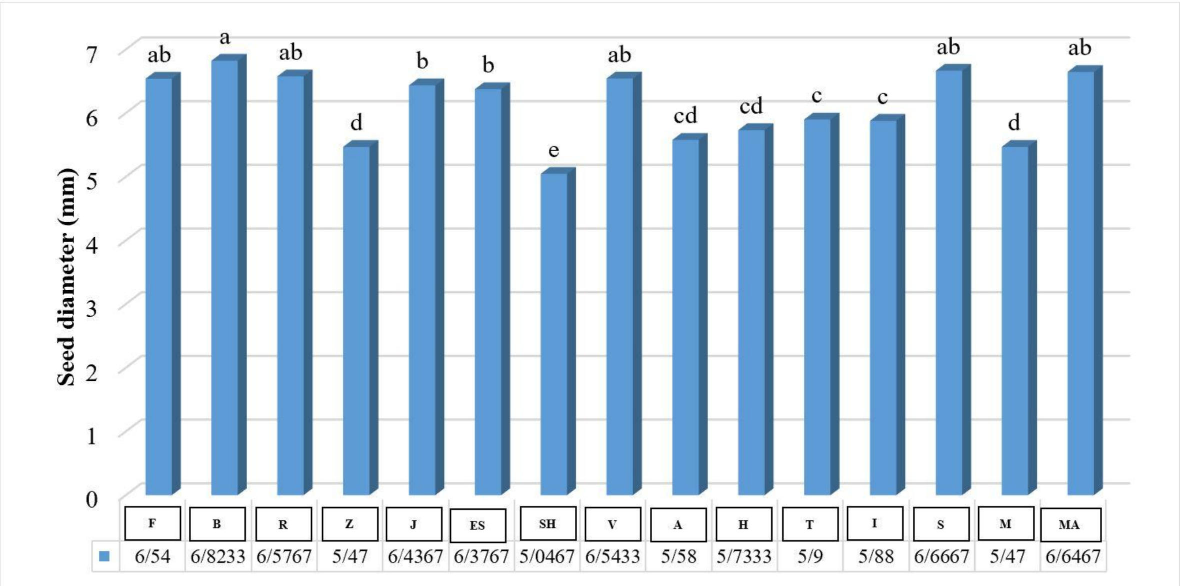

Figure 9. Average comparison of castor genotypes in terms of seed diameter trait. Fars (F), Borkhar(B), Rezen (R), Zahedan(Z), Jiroft(J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan(H), Tabriz(T), Iranshahr(I), Sari(S), Malayer(M), Tabri (T) and Mashhad (MA)

The weight of one thousand seeds

The results of the analysis of variance indicated the existence of a significant difference between the average genotypes (Table 4). The comparison of the averages also confirmed this and showed that the Mashhad genotype has the highest weight of 1000 seeds with 524.61 grams. On the other hand, Shahrekord genotype had the lowest average weight of 1000 seeds with 132.72 grams. Other genotypes were intermediate between Mashhad and Shahrekord genotypes (Figure 10). The increased weight of 1,000 seeds also significantly increases the grain yield. The findings of most researchers indicate the existence of a direct and significant relationship between the weight of one thousand seeds and seed yield (Bolaji *et al*., 2018). The seed yield of a plant is an important and very complex trait that is the result of the interaction of many plant traits and this complex trait is affected by various factors including genotype (Jabari *et al*., 2007; Jahanvard *et al*., 2009). López Pereira *et al*. (2000) mentioned the number of seeds and the weight of 1000 seeds as the most important factors affecting the seed yield of different sunflower hybrids. Some phenological (Singh and Miller, 1981), morphological (Jabari *et al*., 2007) and physiological (Rousseaux *et al*., 2000) characteristics can also play an important role in sunflower seed yield, which can also be true for castor. In addition, climate also influences capsule size and ultimately the weight of 1,000 seeds. As the results showed, the Shahrekord genotype produced few capsules with small seeds due to its morphological characteristics and incompatibility with the Isfahan climate, and finally, the 1000 seed weight of this genotype was lower than the rest of the genotypes.

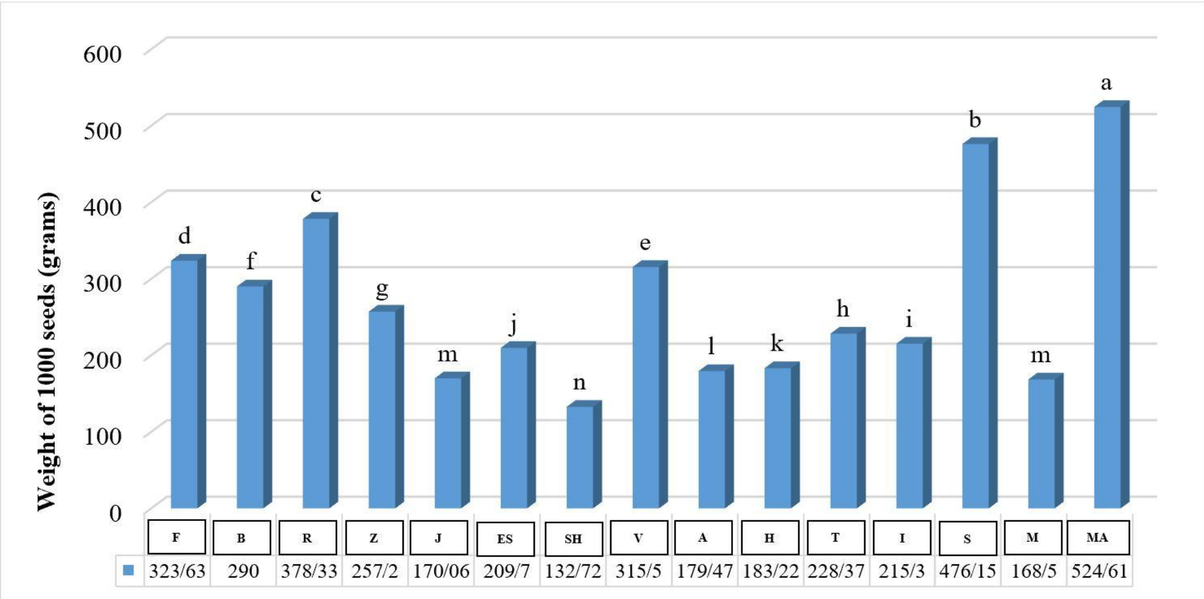

Figure 10. Average comparison of castor genotypes in terms of 1000 seed weight trait. Fars(F), Borkhar(B), Rezen (R), Zahedan (Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin(V),

Abarkooh (A), Hamadan(H), Tabriz(T), Iranshahr(I), Sari(S), Malayer(M), Tabri (T) and Mashhad (MA)

Cross section of stem

Variance analysis showed significant differences between castor genotypes in terms of stem cross-sectional area trait (Table 4). The comparison of the averages showed that the Jiroft genotype has the highest cross-sectional area of the stem with 3 square centimeters. On the other hand, Shahrekord genotype had the lowest stem cross-sectional area (1.3 cm2) (Figure 11). Other genotypes were intermediate between these two genotypes. Maekine research (1998) indicated that the growth of the cross-sectional area of the stem is determined by the temperature during the summer months, and the temperature has the greatest effect on the radial growth of the stem. Also, the presence of some plant growth regulators leads to increased cell division in the plant. The results of the cultivation of different genotypes of castor plants in Isfahan region indicated that the Shahrekord genotype has the lowest stem cross-section due to the cool weather in Shahrekord and the effect on its genetics. Consequently, we can say that this trait is the result of genotype-climate interactions.

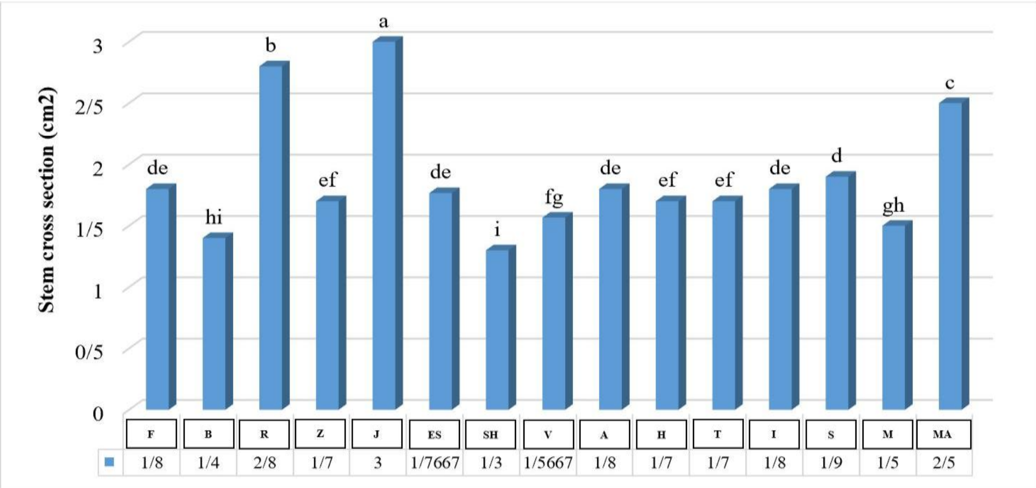

Figure 11. Comparison of average castor genotypes in terms of stem cross-sectional area trait. Fars (F), Borkhar (B), Rezen (R), Zahedan(Z), Jiroft (J), Isfahan (Es), Shahrekord (SH), Varamin (V), Abarkooh (A), Hamadan (H), Tabriz (T), Iranshahr (I), Sari (S), Malayer (M), Tabri (T) and Mashhad (MA)

Capsule size

Variance analysis indicated a significant difference between the mean genotypes in terms of capsule size (Table 4). The comparison of the averages also confirmed the existence of great differences between genotypes in terms of this characteristic. The results showed that Fars, Jiroft and Mashhad genotypes had the largest capsule size at 2.6 cm and were placed in the same statistical group. On the other hand, Malayer genotype with a 1 cm capsule size had the lowest average of this characteristic (Figure 12). It should be noted that high humidity and long days increase the percentage of female flowers (Arshi, 1988; Weisz, 2000). Shidfar *et al*. (2013) reported in research that the highest percentage of flowers of castor plants belongs to the Fasa variety. The high percentage of female flowers in the Fasa variety is due to the genetic characteristics of this variety, and in this regard, Vanderwerf *et al*. (1995) stated that the number of cluster flowers depends on the variety and cultivation conditions. When there are favorable growth conditions, the percentage of male and female flowers increases and as a result, the clusters are full of flowers and more capsules are created. According to the obtained results, it seems that the climate of Isfahan has provided suitable conditions for the growth of flowers of Fars, Jiroft and Mashhad genotypes compared to other genotypes, which increased the length and number of capsules.

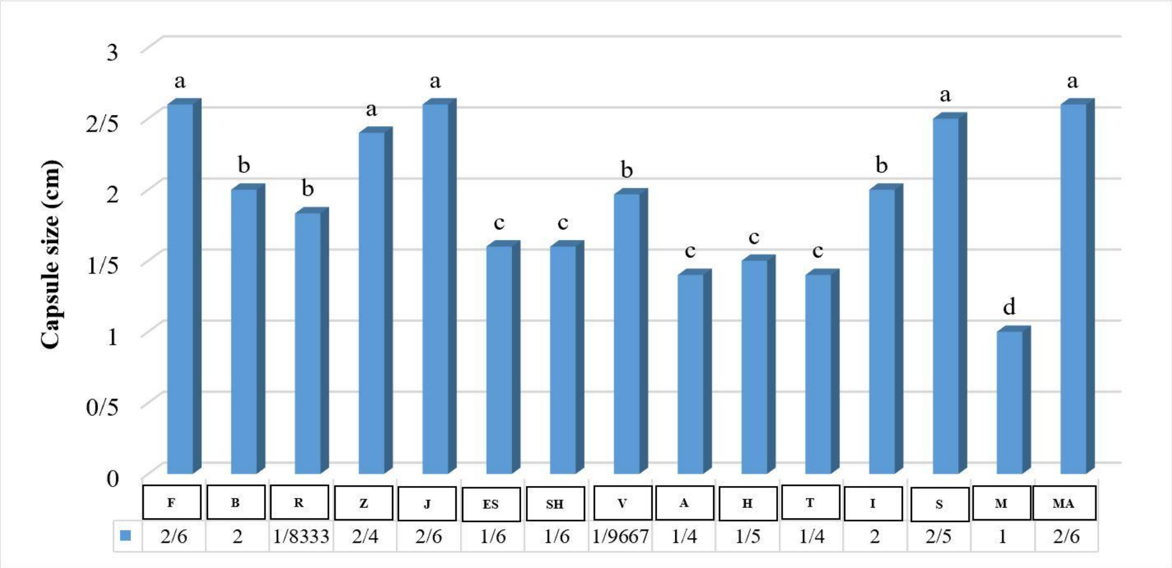

Figure 12. Comparison of average castor genotypes in terms of capsule size trait. Fars(F), Borkhar(B), Rezen (R), Zahedan(Z), Jiroft(J), Isfahan (Es), Shahrekord (SH), Varamin(V), Abarkooh (A), Hamadan(H), Tabriz(T), Iranshahr(I), Sari(S), Malayer (M), Tabri (T) and Mashhad (MA)

CONCLUSION

This research was carried out to evaluate the morphological traits in some castor genotypes in the climatic conditions of Isfahan. Sari and Rezen genotypes had longer seed lengths than other genotypes due to growth in temperate regions. The reason for this can be considerable phenotypic and genotypic diversity, as well as the interaction of climate and genotype, which is effective in increasing the length of the seed and the height of the cluster and sub-branches. Fars, Jiroft and Mashhad genotypes had the largest capsule size. The reason for this is the length of the day and high humidity, the right climate and favorable growing conditions. The number of spikes is one of the components of seed yield in castor, and Jiroft genotype has the highest number of spikes, cross-sectional area and spike length. It can be said that the supply of water, the climate of the place of cultivation, timely cultivation and plant growth regulators in this genotype is the reason that it can affect vegetative growth. The highest number of leaves was observed in Mashhad, Shahrekord, and Zahedan genotypes, respectively, which is due to the adaptation to the weather. Also, the highest number of sub-branches belong to Mashhad, Iranshahr and Jiroft genotypes respectively, which can be said to be the reason for this highly competitive power and better use of environmental conditions. According to the obtained results, it can be concluded that the morphological characteristics, water requirement supply, the climate of the cultivation place and the correlation of 1000 seed weight with seed yield in castor plant are effective on the number of clusters, the number of capsules, the number of leaves and the 1000 seed weight. Therefore, it can be said that Different genotypes, environmental adaptations and synthesis of plant growth regulators under favorable climatic conditions led to vegetative growth and high yields in some genotypes, including Isfahan genotype.

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